

SPECIFICATION

Circuit for controlling a current source transistor

- 5 This invention relates to a circuit for controlling a current source transistor.

A large number of circuits are known for the production of temperature-compensated transistor currents. The temperature is compensated for example, by applying bias voltages at the base-emitter paths of the transistors, through which constant currents have flowed, at diode paths operated in the direction of flow, these diode paths having the same temperature characteristics as the transistors.

- 10 However it is not absolutely certain from this temperature compensation that the currents flowing through the transistors are independent of the magnitude of the d.c. supply voltage. This is because the current sources do not have an infinitely large resistance and moreover, as the collector emitter voltages across the transistors increase, which may be caused for example by the increase in the d.c. supply voltage, the collector current through these transistors rises because of the current voltage characteristics which are specific to the component. In a push-pull output stage, this means, for example, that the collector quiescent current also rises through the output stage transistors as operating voltage rises even if this collector quiescent current is produced with the aid of a temperature-stabilising circuit. This undesirable increase in the quiescent collector current through output stage transistors of the push-pull output stage may lead to self-destruction of the output stage transistors as the operating voltage rises.

The present invention seeks to provide a circuit by means of which the currents through current source transistors may be controlled as a function of the d.c. supply voltage. Thus the transistor current may either remain constant or even become smaller as the d.c. supply voltage begins to rise.

- According to the invention there is provided a circuit for controlling a current source transistor as a function of the d.c. supply voltage, wherein a further transistor current source is connected to the d.c. supply voltage and supplies a control component with current, the control voltage for the current source transistor depending on the voltage drop across this component and a controlled resistance which is controllable in dependence on the supply voltage is connected in parallel with the said component.

The control voltage for the controllable resistor, which is preferably a transistor, may be tapped off at a voltage divider connected between the poles of the supply voltage source. In order to save current, this voltage divider may, at the same time, form the series resistance of the additional current source.

- As the component across which the control voltage for the current source transistor or current source transistors drops, a semi-conductor diode which is connected in parallel to the base-emitter path of the current source transistor and which has the same temperature characteristics as the current source transistors may be used to bring about

temperature compensation of the transistor current at the same time in this way. The series resistance of the second current source may comprise the voltage divider which has already been mentioned while the base of a transistor may be connected to the tapping of this voltage divider. This transistor may be connected in parallel with the diode which controls the current source transistor and thus take over the function of a controllable resistor.

- The above circuit is preferably so dimensioned that the current through the current source transistor or, if necessary also through several current source transistors, remains constant when the d.c. supply voltage changes or even decreases slightly for the purpose of overcompensating. With this circuit, the currents, in particular, may be controlled and serve to produce an initial voltage for the base emitter paths of the output stage transistors in a push-pull output stage circuit.

The invention will now be described in greater detail by way of example, with reference to the drawings, in which:—

Figure 1 shows the part of the circuit which is essential to the invention, and

- Figure 2 shows in greater detail how the collector quiescent current may be affected by the output stage transistors of a push-pull output stage circuit using the circuit in accordance with the invention.

In Figure 1, two current source transistors T_1 and T_2 are shown which supply loads V_1 or V_2 , which lie in the collector circuit the transistors, with current. These current sources are connected to a d.c. voltage source. The base-emitter initial voltage of the transistors T_1 and T_2 is obtained at a diode D_0 . This diode draws its current via a further constant current source which comprises, for example, transistors T_7 and T_8 . Thus the collector-base path of one transistor T_7 is connected in parallel with the base-emitter path of the other transistor T_8 . Both transistors have an emitter resistor R_6 or R_7 respectively. A series resistor lying in the collector branch of the transistor T_7 is constructed as a voltage divider R_3, R_4 . The base electrode of a transistor T_6 is connected to the tapping of this voltage divider at the connection between the resistors R_3 and R_4 , the transistor T_6 being connected together with its emitter-resistor R_5 in parallel with the diode D_0 . In the example shown, the transistors T_1, T_2 and T_6 are pnp-transistors while transistors T_7 and T_8 are npn-transistors.

- With a constant d.c. supply voltage U_B , a temperature-stabilized constant current flows through transistors T_1 and T_2 . The diode D_0 , the temperature characteristics of which must agree with the temperature characteristics of the transistors T_1 and T_2 , ensures temperature stabilization.

However if the d.c. supply voltage changes, then the current I_1 or I_2 respectively changes because of the characteristics of transistors and because of the internal resistance of the current source circuits, which internal resistance is not infinitely large. As U_{CE} increases at the transistors T_1 and T_2 , the current I_C usually rises. The circuit member A serves to compensate or overcompensate for this effect. In this circuit, current through the voltage divider R_3, R_4 is almost proportional to the d.c. supply voltage U_B .

As the d.c. supply voltage rises the voltage drop across resistor R_3 also rises. As a result, the transistor T_6 is controlled progressively into its conductive condition. Thus current is drawn from diode D_0 so that the voltage drop across this diode is less and the current source transistors T_1 and T_2 are therefore controlled to have smaller collector currents. The circuit member A may be so dimensioned that, as the d.c. supply voltage U_B rises, the currents I_1 and I_2 through the transistors T_1 and T_2 remain constant. Overcompensation may also be achieved with appropriate choice of values, i.e. the current through transistors I_1 and I_2 may be made to become less as the d.c. supply voltage rises further.

From the circuit according to Fig. 2, another advantageous method of using the stabilizing circuit in accordance with the invention is apparent.

The stabilizing circuit A is connected to a push-pull-B-output stage. As small a collector quiescent current as possible should flow through the output stage transistors T_{11} and T_{12} , the said collector quiescent current being independent of the temperature or the d.c. supply voltage U_B . Compensation for temperature is achieved, as was already mentioned, by obtaining the initial voltages at the diode paths operated in the forward direction, these diode paths having the same temperature characteristics as the transistors.

The circuit according to Figure 2 in turn has transistors T_1 and T_2 which may be compared with those of the circuit according to Fig. 1. The diode D_1 and the transistor T_5 , whose base is controlled by the low-frequency signal, lie in the collector path of the transistor T_1 . The signal tapped off at the collector of the transistor T_5 is passed to the base of the transistor T_3 , which has a resistor R_1 in its collector path, the base-emitter initial voltage for the end stage transistor T_{12} drops across the resistor R_1 . The emitter of a further transistor T_4 is connected after the emitter of the transistor T_3 and its collector is connected to the d.c. voltage source. In the base branch of the transistor T_4 there lie diodes D_2 and D_3 which are connected to the centre tapping of the two output stage transistors T_{11} and T_{12} . Furthermore, the collector of the transistor T_2 is connected to the base electrode of the transistor T_4 , the current I_2 flowing in this transistor T_2 . The circuit which comprises a diode D_4 , a transistor T_9 with its collector resistor R_2 and a transistor T_{10} , serves to control the transistor T_{11} . The diode D_4 thus determines the base-emitter voltage of the transistor T_9 , the stabilized base-emitter initial voltage of the output stage transistor T_{11} dropping across the collector resistor R_2 of the transistor T_9 . The transistor T_{10} , which is connected in series with the diode D_4 , is controlled at the base by means of the diode D_1 .

Transistors T_3 and T_4 are complementary transistors.

Transistors T_1 , T_2 , T_6 , T_9 and T_3 are pnp-transistors, for example while transistors T_4 , T_5 , T_7 , T_8 , T_{10} , T_{11} and T_{12} are npn-transistors. The circuit may also be constructed with transistors of the opposite type of conductivity respectively. The diodes D_1 , D_2 and D_3 are operated in the forward direction and serve to

produce the initial voltage for the transistors T_3 , T_4 and T_{10} . The diodes obtain their flow currents from the current sources I_1 and I_2 .

The diodes D_1 to D_3 and the base emitter paths of the transistors T_3 , T_4 and T_{10} form a closed circuit; additions of all of the voltage drops within this circuit equals zero. The base-emitter initial voltages for the transistors T_{11} and T_{12} , which are required for the actual push-pull-B-output stage transistor T_{11} and T_{12} in order to set a small collector quiescent current of only a few, mA, are formed across the resistors R_1 and R_2 . These voltages are temperature-stabilized because the diodes used in the circuit have the same temperature characteristics as the transistors. In the manner already described, the collector quiescent current through the output stage transistors T_{11} and T_{12} become moreover independent of the magnitude of the d.c. supply voltage U_B with the aid of the circuit member A.

CLAIMS

1. A circuit for controlling a current source transistor as a function of the d.c. supply voltage, wherein a further transistor current source is connected to the d.c. supply voltage and supplies a control component with current, the control voltage for the current source transistor depending on the voltage drop across this component and a controlled resistance which is controllable in dependence on the supply voltage is connected in parallel with the said component.

2. A circuit as claimed in Claim 1, wherein the said component is a semiconductor diode which is connected in parallel with the base emitter path of the said current source transistor and which has the same temperature characteristics as said current source transistor.

3. A circuit as claimed in Claim 2, wherein the series resistance of the further current source comprises a voltage divider and the base of an additional transistor is connected to the tapping of said voltage divider, the collector emitter path of the 1 additional transistor being connected in parallel with the diode controlling the current source transistor.

4. A circuit as claimed in Claim 3, wherein the series connection comprising the collector emitter path of the additional transistor and an emitter resistor is connected in parallel with said diode.

5. A circuit as defined in Claim 4, wherein the further current source comprises first and second transistors, the collector base path of the first transistor, whose collector resistor comprises the voltage divider, being connected in parallel with the base-emitter path of the second transistor in whose collector branch the diode is located; and both transistors are connected to a reference potential via an emitter resistor.

6. A circuit as claimed in any one of Claims 1 to 5, wherein the circuit has such values that the current through the current source transistor either remains constant or decreases as the d.c. supply voltage changes.

7. A control circuit for controlling the currents serving to produce a voltage for the base emitter paths output stage transistors in a push-pull output stage and including a circuit as claimed in any one of



As the d.c. supply voltage rises the voltage drop across resistor R_3 also rises. As a result, the transistor T_6 is controlled progressively into its conductive condition. Thus current is drawn from diode D_0 so that the voltage drop across this diode is less and the current source transistors T_1 and T_2 are therefore controlled to have smaller collector currents. The circuit member A may be so dimensioned that, as the d.c. supply voltage U_B rises, the currents I_1 and I_2 through the transistors T_1 and T_2 remain constant. Overcompensation may also be achieved with appropriate choice of values, i.e. the current through transistors I_1 and I_2 may be made to become less as the d.c. supply voltage rises further.

From the circuit according to Fig. 2, another advantageous method of using the stabilizing circuit in accordance with the invention is apparent.

The stabilizing circuit A is connected to a push-pull-B-output stage. As small a collector quiescent current as possible should flow through the output stage transistors T_{11} and T_{12} , the said collector quiescent current being independent of the temperature or the d.c. supply voltage U_B . Compensation for temperature is achieved, as was already mentioned, by obtaining the initial voltages at the diode paths operated in the forward direction, these diode paths having the same temperature characteristics as the transistors.

The circuit according to Figure 2 in turn has transistors T_1 and T_2 which may be compared with those of the circuit according to Fig. 1. The diode D_1 and the transistor T_5 , whose base is controlled by the low-frequency signal, lie in the collector path of the transistor T_1 . The signal tapped off at the collector of the transistor T_5 is passed to the base of the transistor T_3 , which has a resistor R_1 in its collector path, the base-emitter initial voltage for the end stage transistor T_{12} drops across the resistor R_1 . The emitter of a further transistor T_4 is connected after the emitter of the transistor T_3 and its collector is connected to the d.c. voltage source. In the base branch of the transistor T_4 there lie diodes D_2 and D_3 which are connected to the centre tapping of the two output stage transistors T_{11} and T_{12} . Furthermore, the collector of the transistor T_2 is connected to the base electrode of the transistor T_4 , the current I_2 flowing in this transistor T_2 . The circuit which comprises a diode D_4 , a transistor T_9 with its collector resistor R_2 and a transistor T_{10} , serves to control the transistor T_{11} . The diode D_4 thus determines the base-emitter voltage of the transistor T_9 , the stabilized base-emitter initial voltage of the output stage transistor T_{11} dropping across the collector resistor R_2 of the transistor T_9 . The transistor T_{10} , which is connected in series with the diode D_4 , is controlled at the base by means of the diode D_1 .

Transistors T_3 and T_4 are complementary transistors.

Transistors T_1 , T_2 , T_6 , T_9 and T_3 are pnp-transistors, for example while transistors T_4 , T_5 , T_7 , T_8 , T_{10} , T_{11} and T_{12} are npn-transistors. The circuit may also be constructed with transistors of the opposite type of conductivity respectively. The diodes D_1 , D_2 and D_3 are operated in the forward direction and serve to

produce the initial voltage for the transistors T_3 , T_4 and T_{10} . The diodes obtain their flow currents from the current sources I_1 and I_2 .

The diodes D_1 to D_3 and the base emitter paths of the transistors T_3 , T_4 and T_{10} form a closed circuit; additions of all of the voltage drops within this circuit equals zero. The base-emitter initial voltages for the transistors T_{11} and T_{12} , which are required for the actual push-pull-B-output stage transistor T_{11} and T_{12} in order to set a small collector quiescent current of only a few, mA, are formed across the resistors R_1 and R_2 . These voltages are temperature-stabilized because the diodes used in the circuit have the same temperature characteristics as the transistors. In the manner already described, the collector quiescent current through the output stage transistors T_{11} and T_{12} become moreover independent of the magnitude of the d.c. supply voltage U_B with the aid of the circuit member A.

CLAIMS

1. A circuit for controlling a current source transistor as a function of the d.c. supply voltage, wherein a further transistor current source is connected to the d.c. supply voltage and supplies a control component with current, the control voltage for the current source transistor depending on the voltage drop across this component and a controlled resistance which is controllable in dependence on the supply voltage is connected in parallel with the said component.

2. A circuit as claimed in Claim 1, wherein the said component is a semiconductor diode which is connected in parallel with the base emitter path of the said current source transistor and which has the same temperature characteristics as said current source transistor.

3. A circuit as claimed in Claim 2, wherein the series resistance of the further current source comprises a voltage divider and the base of an additional transistor is connected to the tapping of said voltage divider, the collector emitter path of the 1 additional transistor being connected in parallel with the diode controlling the current source transistor.

4. A circuit as claimed in Claim 3, wherein the series connection comprising the collector emitter path of the additional transistor and an emitter resistor is connected in parallel with said diode.

5. A circuit as defined in Claim 4, wherein the further current source comprises first and second transistors, the collector base path of the first transistor, whose collector resistor comprises the voltage divider, being connected in parallel with the base-emitter path of the second transistor in whose collector branch the diode is located; and both transistors are connected to a reference potential via an emitter resistor.

6. A circuit as claimed in any one of Claims 1 to 5, wherein the circuit has such values that the current through the current source transistor either remains constant or decreases as the d.c. supply voltage changes.

7. A control circuit for controlling the currents serving to produce a voltage for the base emitter paths output stage transistors in a push-pull output stage and including a circuit as claimed in any one of



Claims 1 to 6.

8. A circuit for controlling a current source transistor in dependence on a d.c. supply voltage substantially as described herein with reference to

5 the drawings.

Printed for Her Majesty's Stationery Office by The Tweeddale Press Ltd.,
Berwick-upon-Tweed, 1983.
Published at the Patent Office, 25 Southampton Buildings, London, WC2A 1AY,
from which copies may be obtained.